

# Matrix Characterization of Plutonium Residues by Self-Interrogation and Neutron Activation Analysis

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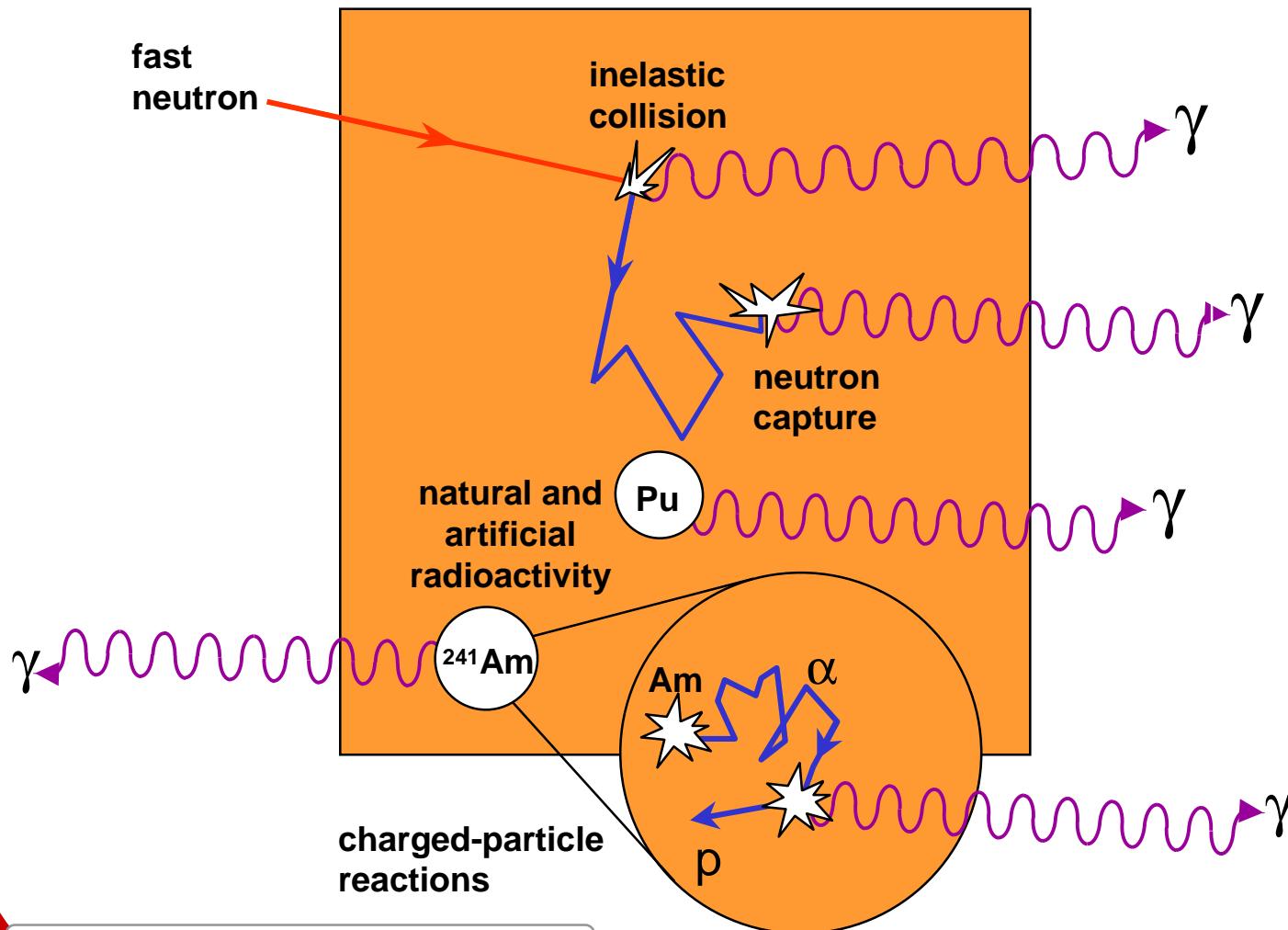
# Objectives

Integrated Surveillance Plan: Identification of containers that may have increased risk of failure under conditions of long-term storage.

Primary considerations are container corrosion and pressurization.

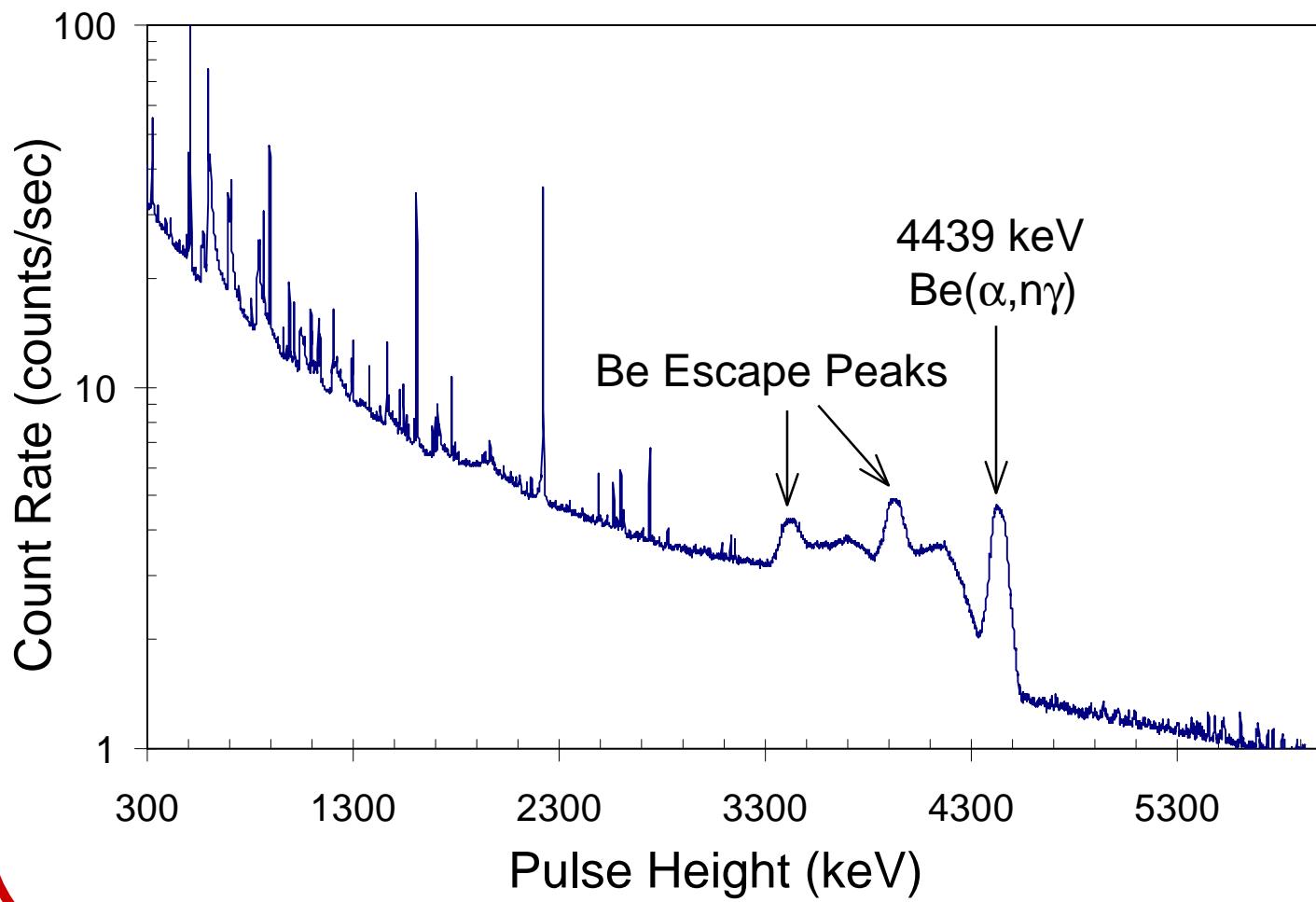
MD Considerations?

## GAMMA-RAYS FROM ITEMS CONTAINING SNM

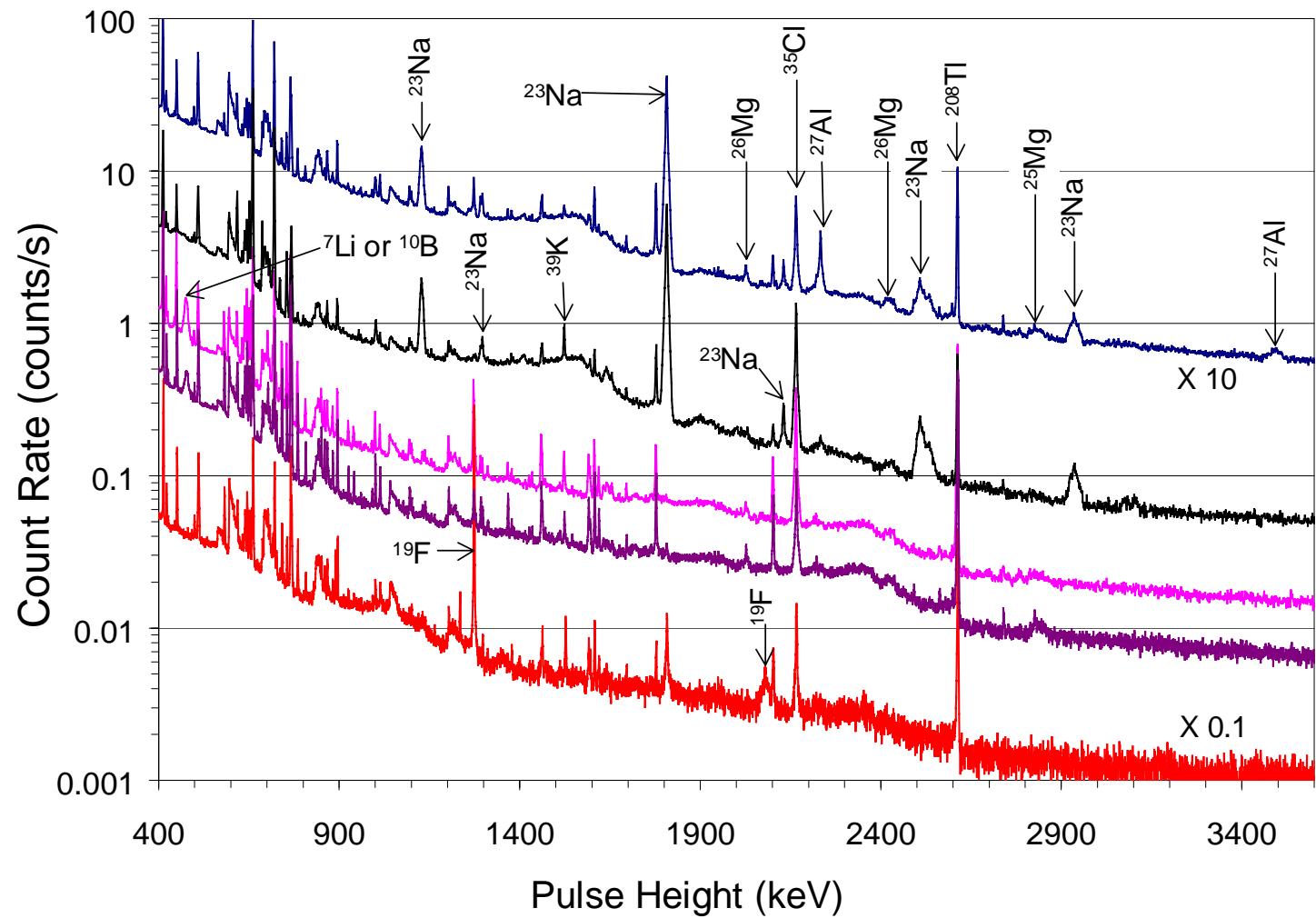


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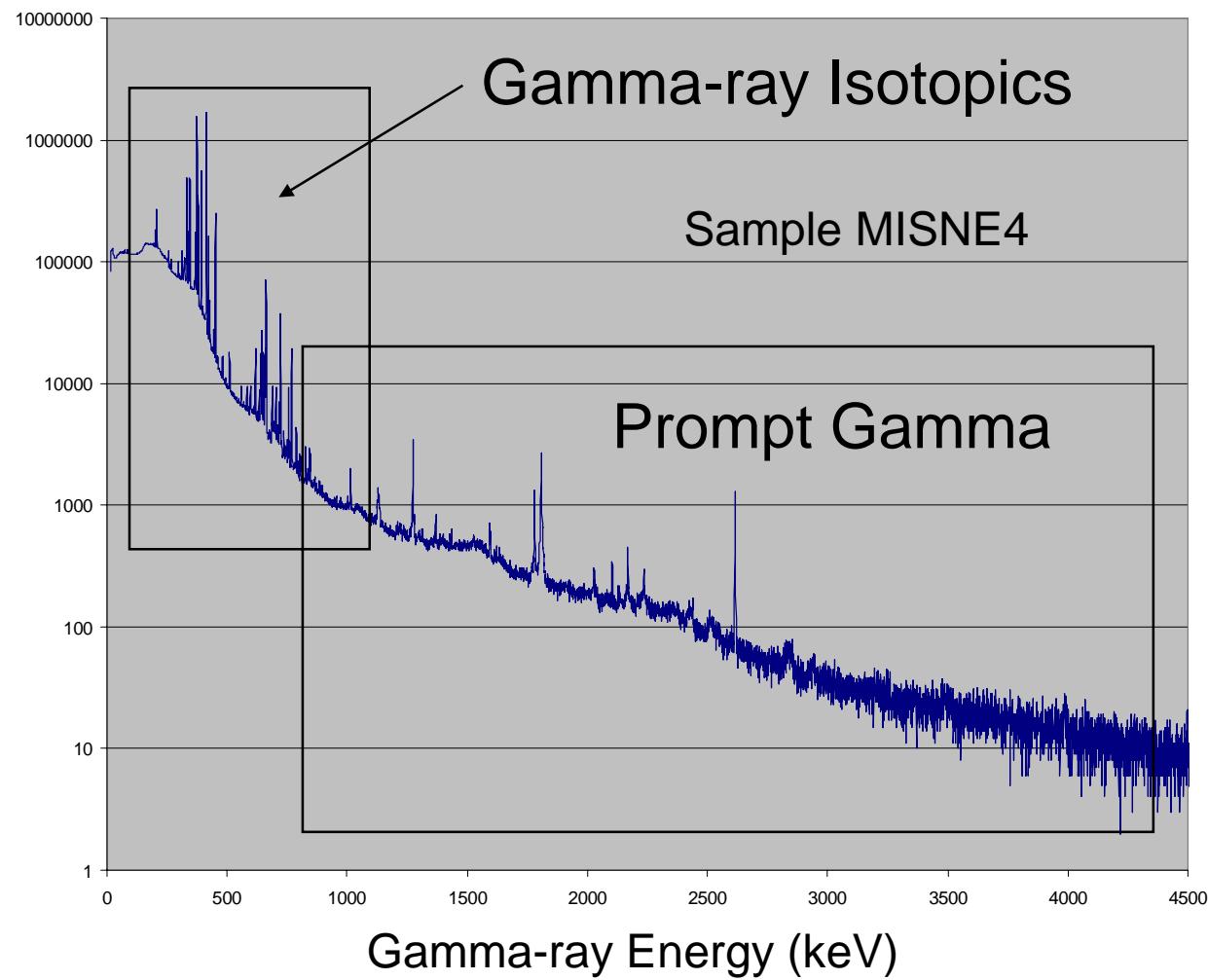
# PuBe Neutron Source



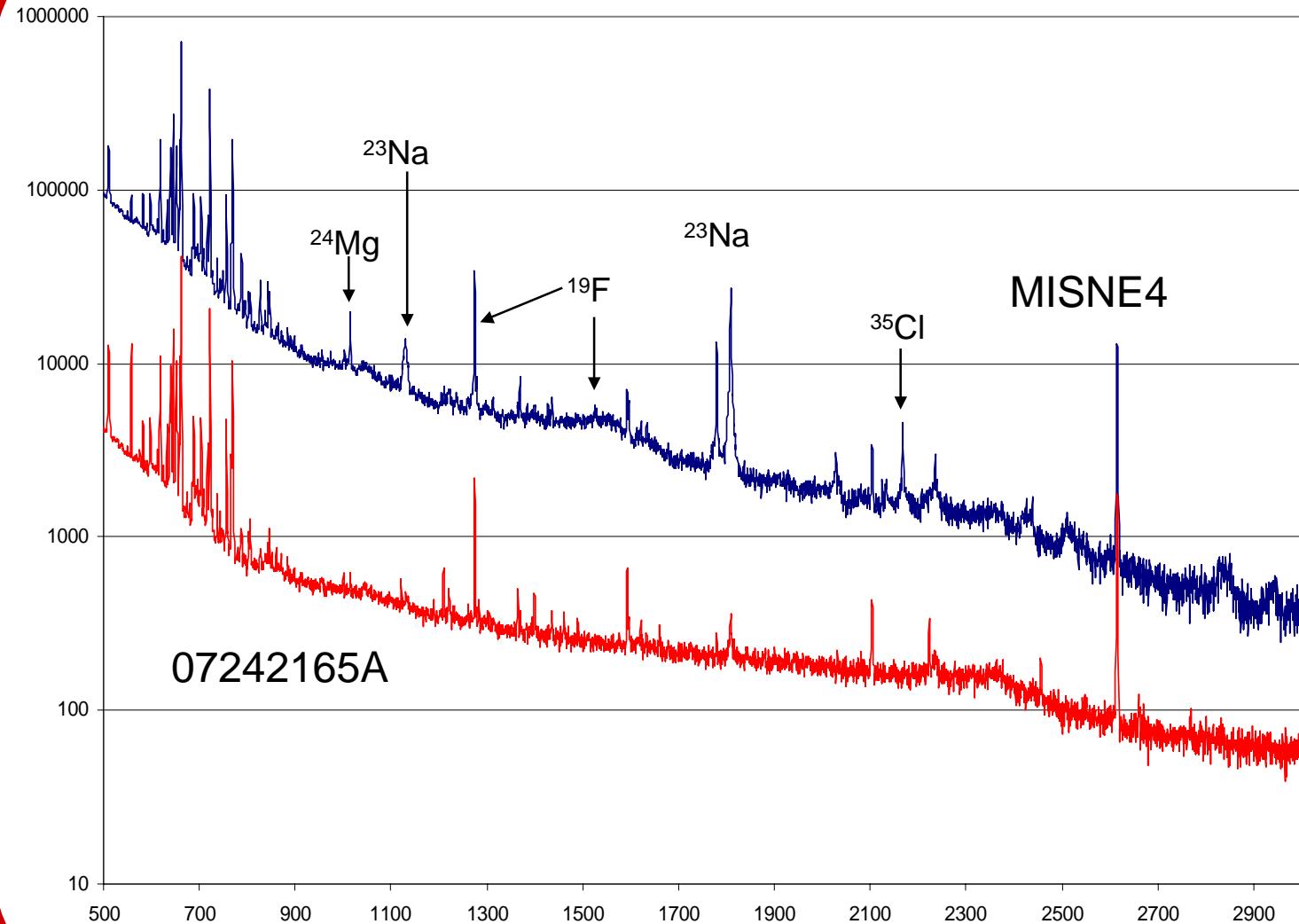
# ER Salt Residues



## Analysis Regions



## Experimental Data using 20% Coaxial Detector



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## Quantitative Analysis

Fairly restrictive conditions must be satisfied to enable quantification of matrix constituents

- Material homogeneity
- Known stoichiometry and particle size
- No large lumps of matrix constituent
- Known alpha-induced gamma-ray thick-target yields for materials of interest.

# Calculations

The mass fraction of the  $i^{\text{th}}$  isotope can be expressed *approximately* as:

$$\left( \frac{\rho_i}{\rho_s} \right) = \frac{CR_i}{\varepsilon_i \left[ \frac{\sigma_i N_A}{A_i} \right] M_{Pu}}$$

Calculations for MIS Items: (Cl as an example.)

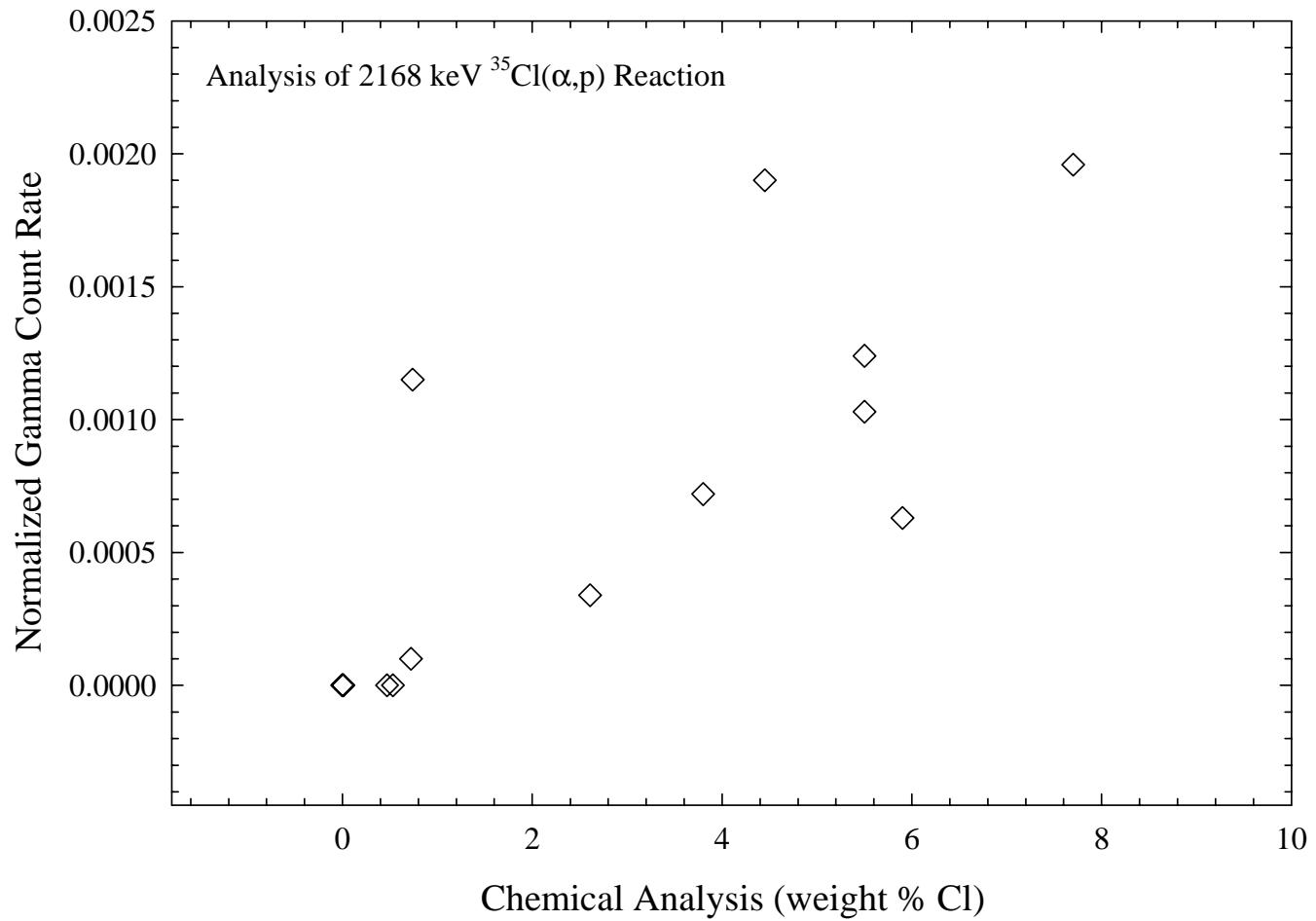
$$\textit{Normalized Count Rate} = \frac{A_{2168}}{LT \cdot M_{Pu}}$$

$A_{2168}$  = Area under 2168 keV peak [ $^{35}\text{Cl}(\alpha, p)$ ]

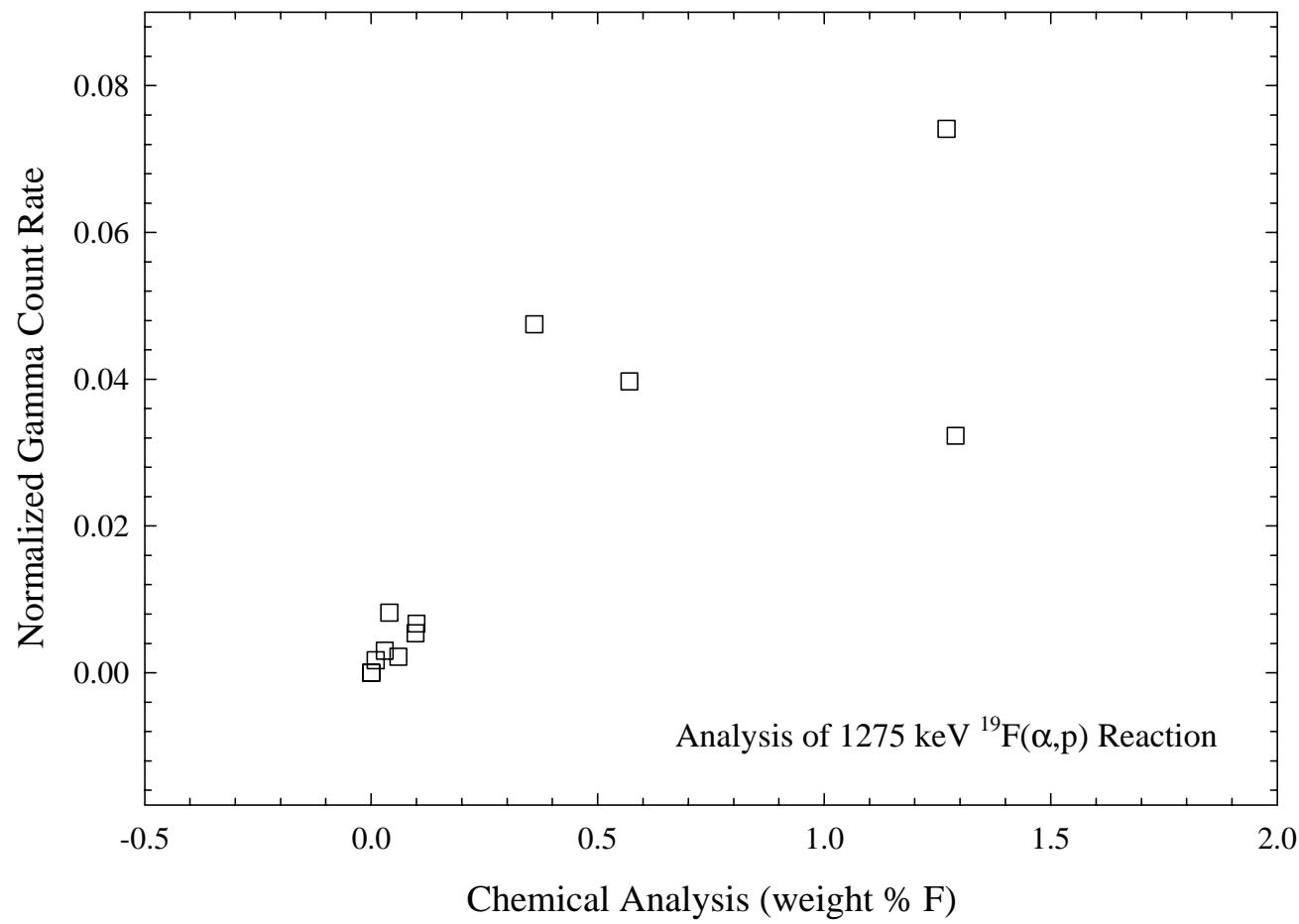
$LT$  = MCA live time

$M_{Pu}$  = mass of plutonium in the sample

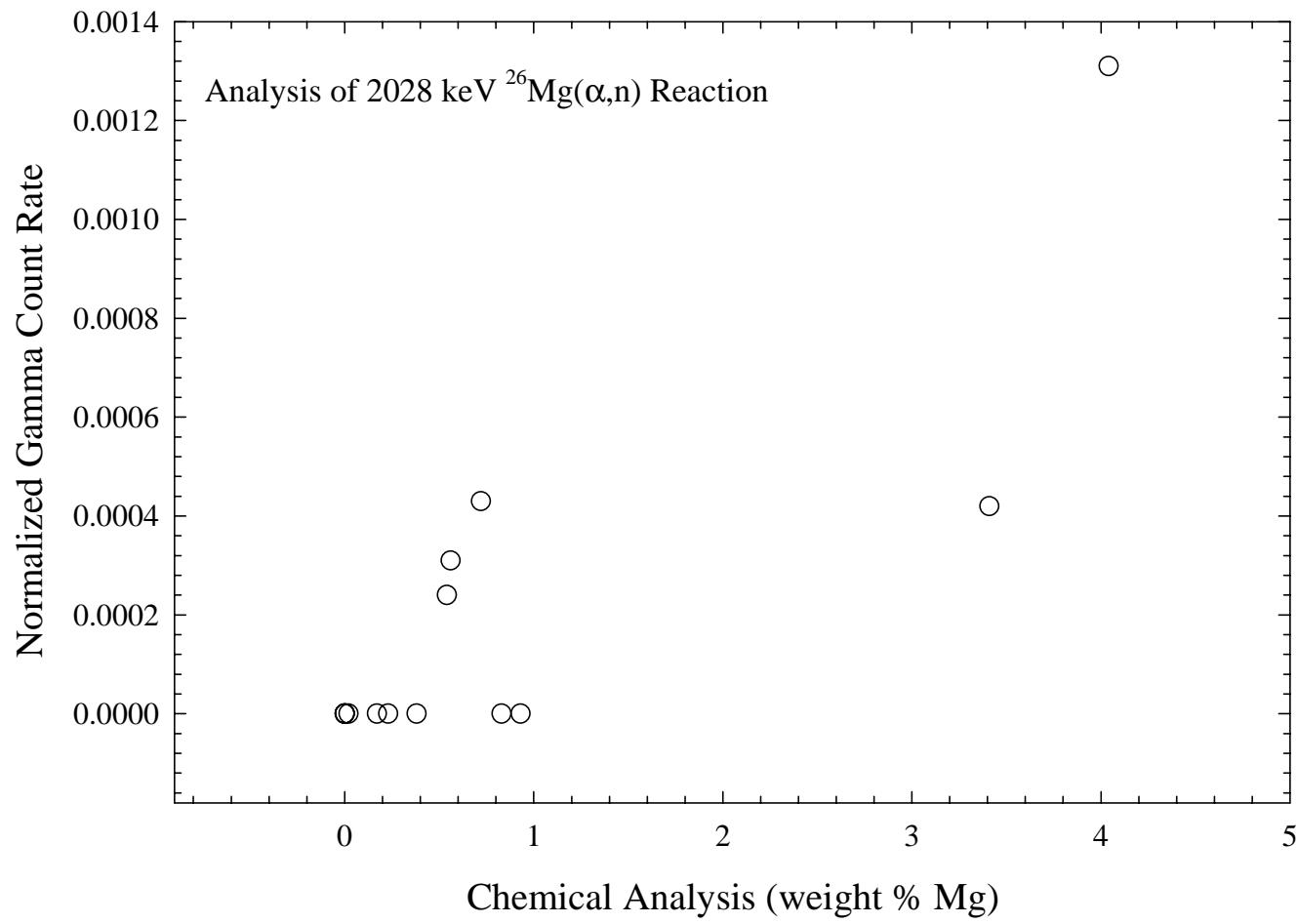
## Prompt-Gamma Chlorine Analysis



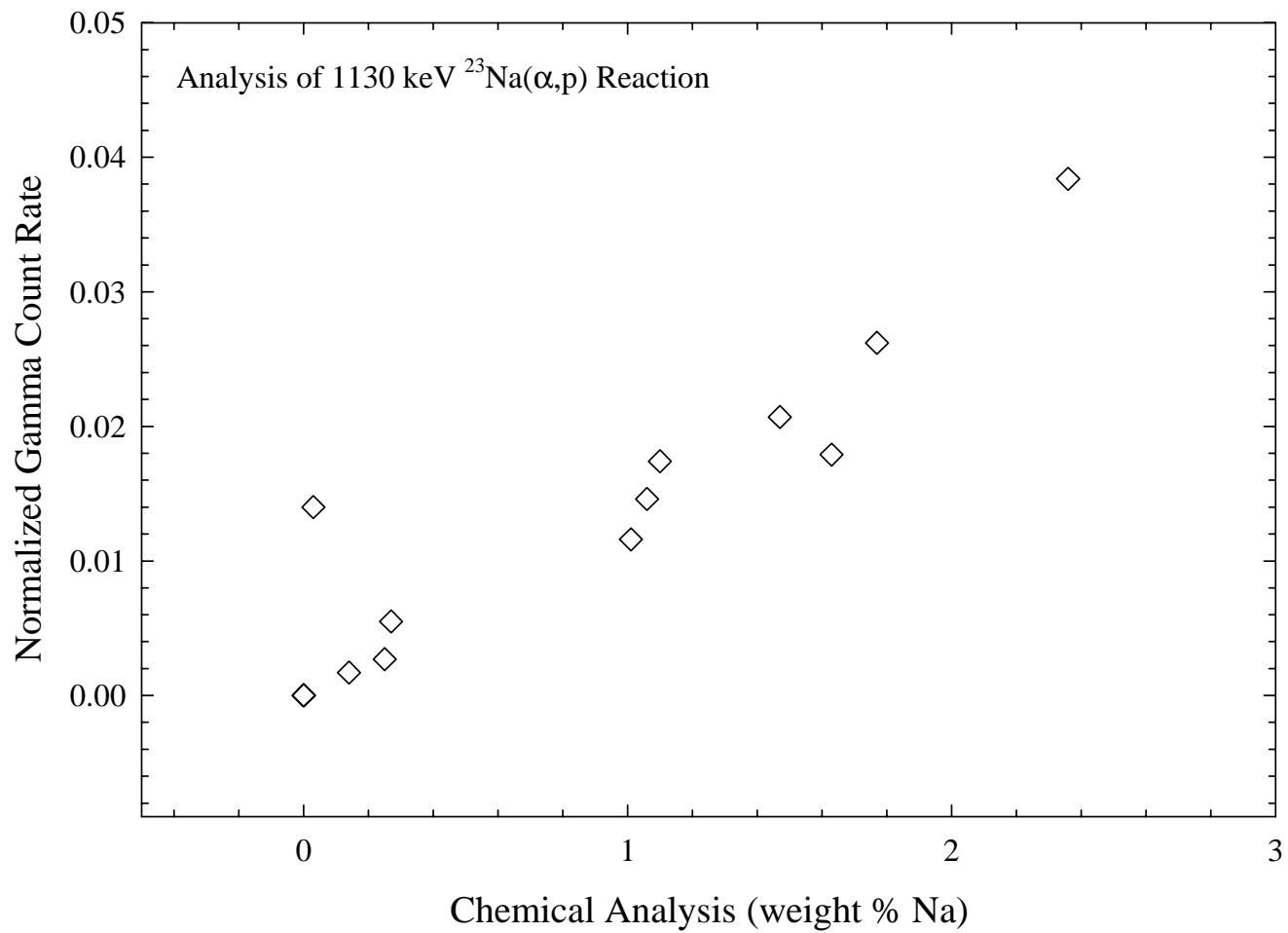
## Prompt-Gamma Fluorine Analysis



## Prompt-Gamma Magnesium Analysis



## Prompt-Gamma Sodium Analysis



# Detection Limits

Elemental detection limits in weight percent for several MIS Program items.

Parameters: 20% Ge detector, count time 3600 seconds.

	PuO <sub>2</sub>	ARF365	MISNE4	ARF295	J2201
g Pu	3023 g	673 g	2754 g	128 g	472 g
Na	< 0.1 %	< 0.1 %	< 0.1 %	< 0.1 %	< 0.1 %
F	< 0.1 %	< 0.1 %	< 0.1 %	< 0.1 %	< 0.1 %
Mg	0.2 %	0.5 %	0.3 %	2.3 %	0.75 %
Cl	0.1 %	0.5 %	0.2 %	1.9 %	0.5 %
Be	< 0.1 %	< 0.1 %	< 0.1 %	< 0.1 %	< 0.1 %

## Recommendations

Minimum practical count time of 1800 seconds -  
3600 seconds preferable to improve analysis.

Coaxial, high-purity, Ge detector with an efficiency  
of ~20% or higher.

Low-energy filter to reduce background from relatively  
low-energy Am and Pu gamma rays.

## SUMMARY AND CONCLUSIONS

Inspection of alpha-induced gamma rays can identify many common matrix constituents in Pu bearing materials.

Alpha-induced gamma-ray spectroscopy can identify items with elevated levels of selected elements that may effect long-term storage, primarily Cl, F, and Mg.

“Quantitative” analysis using alpha-induced gamma rays may be possible if certain conditions are satisfied.

Analysis will be subject to larger uncertainties for more inhomogeneous materials.